Plans for the future of RHIC

T. Ludlam

RHIC/AGS Users Meeting
September 21, 2002

I. Where is the physics taking us?
II. The (Evolving) BNL plan: RHIC II $\Rightarrow$ eRHIC
III. The Nuclear Physics Long Range Plan
IV. The 2002 RHIC Review and subsequent discussions
V. RHIC Upgrades: The current view

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RHIC Future Physics…

RHIC Phase I will be maturing in 2005 – 2006

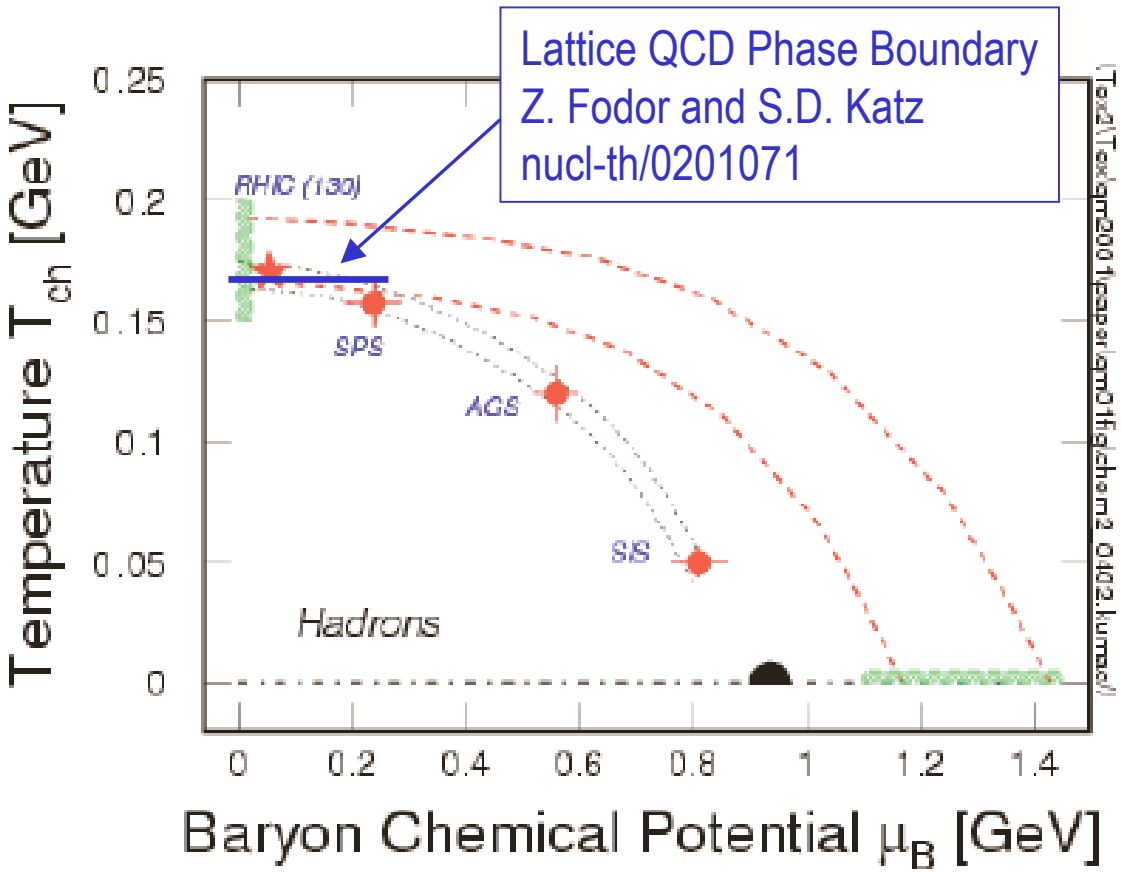
Complete initial runs with Au-Au, p-p, d-Au, energy scan, light ions

- Explore Heavy ion reactions in a new domain
  - Global event characteristics
  - Properties of "hard" physics in A+A

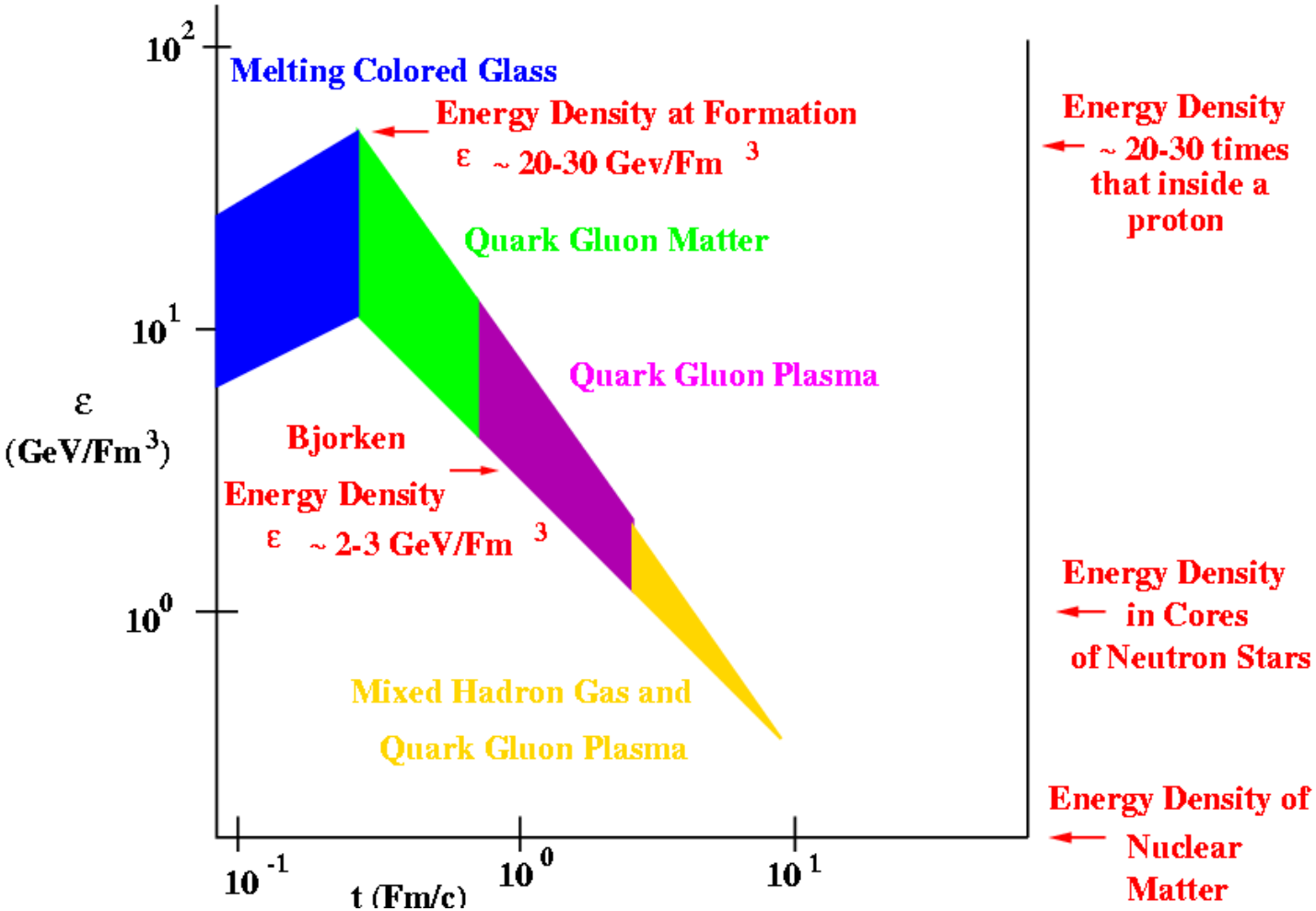
- Discovery phase of the QGP search
  - Establish the early equilibration of matter
  - Demonstrate several characteristic signatures of the QGP
  - Compare with p-A (d-A)

Begin the core Spin program with full machine capability for polarized protons.

Huge Strides Toward the Predicted Realm of the QGP…. Are we there Yet?



A View of the RHIC landscape: peering over the horizon…



Bounds on the energy density as a function of time in heavy ion collisions.
Larry McLerran

The Next Phase… RHIC as a Nuclear QCD Machine: High luminosity A-A, p-A, polarized p-p

- Measure the essential properties of the quark-gluon plasma, and associated phase transitions
- Explore the early phases of reaction dynamics in QCD matter formation
- New phenomena in bulk QCD matter
- Extended studies of nucleon spin structure

Facility requirements:

- ❑ Luminosity and duty factor improvements to allow A A samples ≥ 10 nb^{-1}
- ❑ Upgraded PHENIX, STAR detectors

⇒ New sensitivity to hard scattering, heavy flavors, rare processes

Measurements Beyond the Initial Exploratory Phase

High P_t and Q^2:

- Leading particle/jet spectra to P_t ~30 GeV/c
- Direct photons to P_t > 15 GeV/c
- Photon-tagged jets… *jet tomography*
- Drell-Yan at M ~5 GeV

Rare probes:

- Many x1000 upsilons
- W production in AA pA pp

Very large unbiased event samples:

- Low mass lepton pairs
- γγ interferometry… *Direct EM radiation from plasma*
- Disoriented Chiral Condensate; Strong CP violation

Data samples ~10 nb^{-1} …

Design Lum. (Au Au) … ~160 weeks

4 x L_0 … 40 weeks

40 x L_0 … 4 weeks

Extended detector capability:

- Open charm…
- Flavor tagging of jets…
- Low mass lepton pairs; Low P_t Direct Photons…
- Observables at forward rapidity for spin and pA physics…

Vertex resolution ~0.05 mm

PID at high P_t

Dalitz pair rejection

Forward coverage: tracking, PID

The BNL Plan: RHIC II Concept

Accelerator Components:

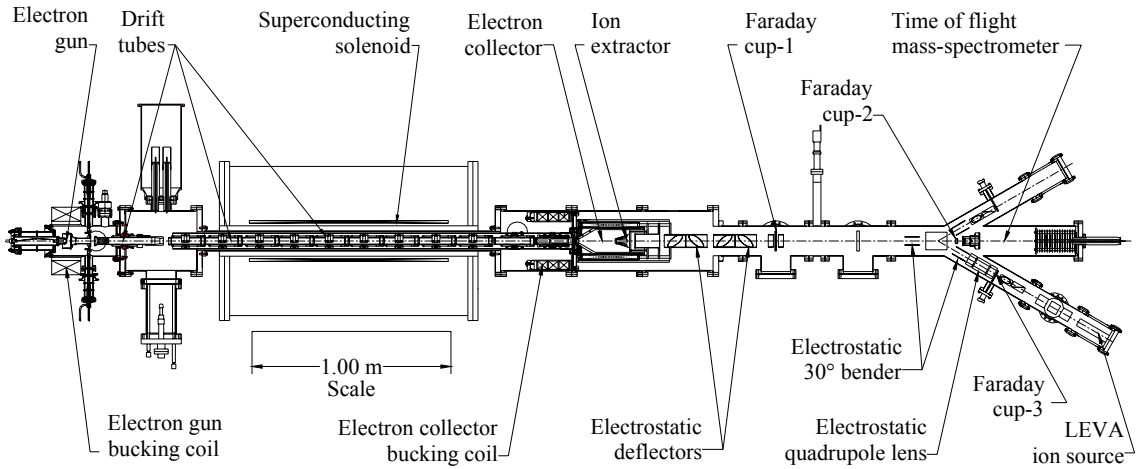
1. Electron beam cooling at full energy
   - Luminosity upgrade to ~40 times RHIC Au-Au design
   - Completion ~2010
   - Cost ~$60M

2. Linac-based pre-injector using EBIS (replaces Tandem)
   - Provides improved performance, low operating cost, and high intensity Uranium beams
   - Cost ~$20M

Detector Components:

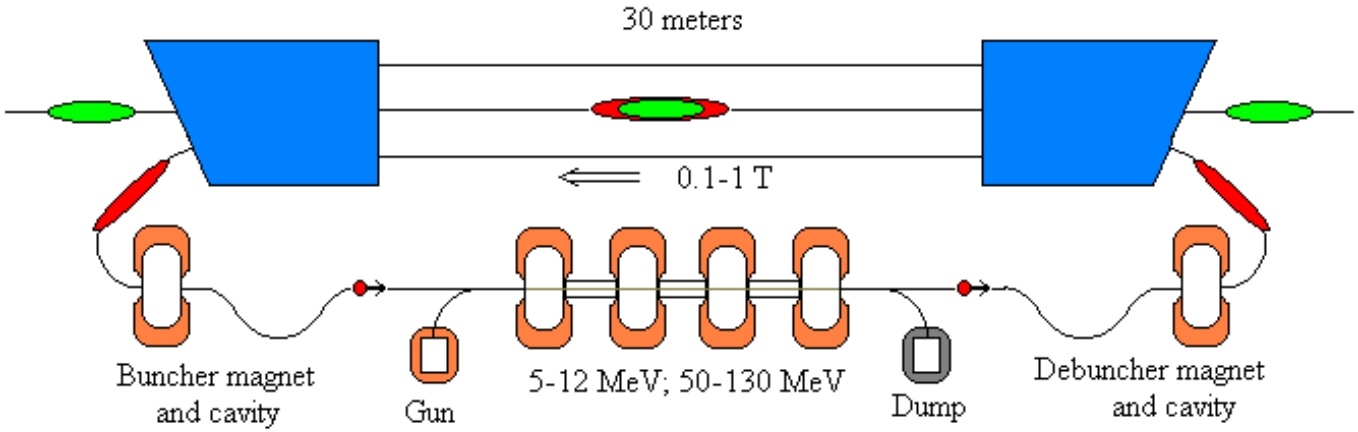
- Major upgrades to PHENIX and STAR for improved sensitivity and rate capability
- Cost ~$80M

Results from Test EBIS (½ of RHIC EBIS)



	RHIC Requirements	Achieved
E-beam current	**10 A**	**10 A**
E-beam energy	**20 keV**	**20 keV**
Yield of pos. charges	**5.5×10^{11} (Au, 10 A, 1.5m)**	**3.2×10^{11} (Au, 8 A, 0.7m)**
Pulse length	**≤ 40 μs**	**20 μs**
Yield of Au^{33+}	**3.4×10^{9}**	**~ 1.5×10^{9}**
Yield of U^{45+}	**2.4×10^{9}**	

The RHIC Electron Beam Cooler



R&D issues:

- Demonstrate high-brightness, high-current CW photocathode electron gun
- Demonstrate high precision (10 ppm) solenoid for 30 m cooling section.

- Full simulation (space charge, non-linearities, wake fields, beam stability) of transport of magnetized electron beam from cathode to dump
- Develop and benchmark cooling simulation codes

RHIC II Luminosity Upgrade Plan

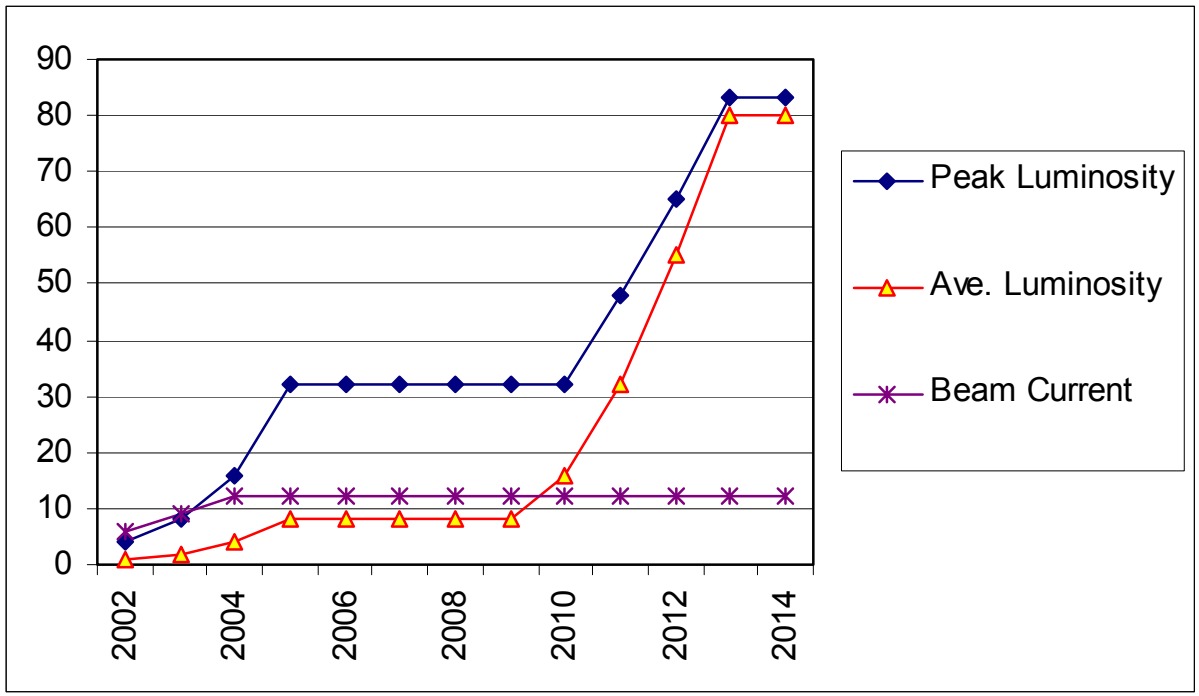
Enhancements possible with existing machine:

Double the number of bunches to 112

Decrease β^* from 2 m to 1m

} 4x increase in ave. L; Still limited by I.B.S.

Electron beam cooling at full RHIC energy will eliminate intra-beam scattering effects and reduce beam emittance: 10x increase in average luminosity



Evolution of Au Au parameters:

Luminosity in units of 10^{26} $cm^{-2}sec^{-1}$

Current in units of 10^{10} ions/beam

PHENIX Detector Requirements for New Physics

- Silicon inner tracking detectors capable of directly measuring open charm and bottom decays.

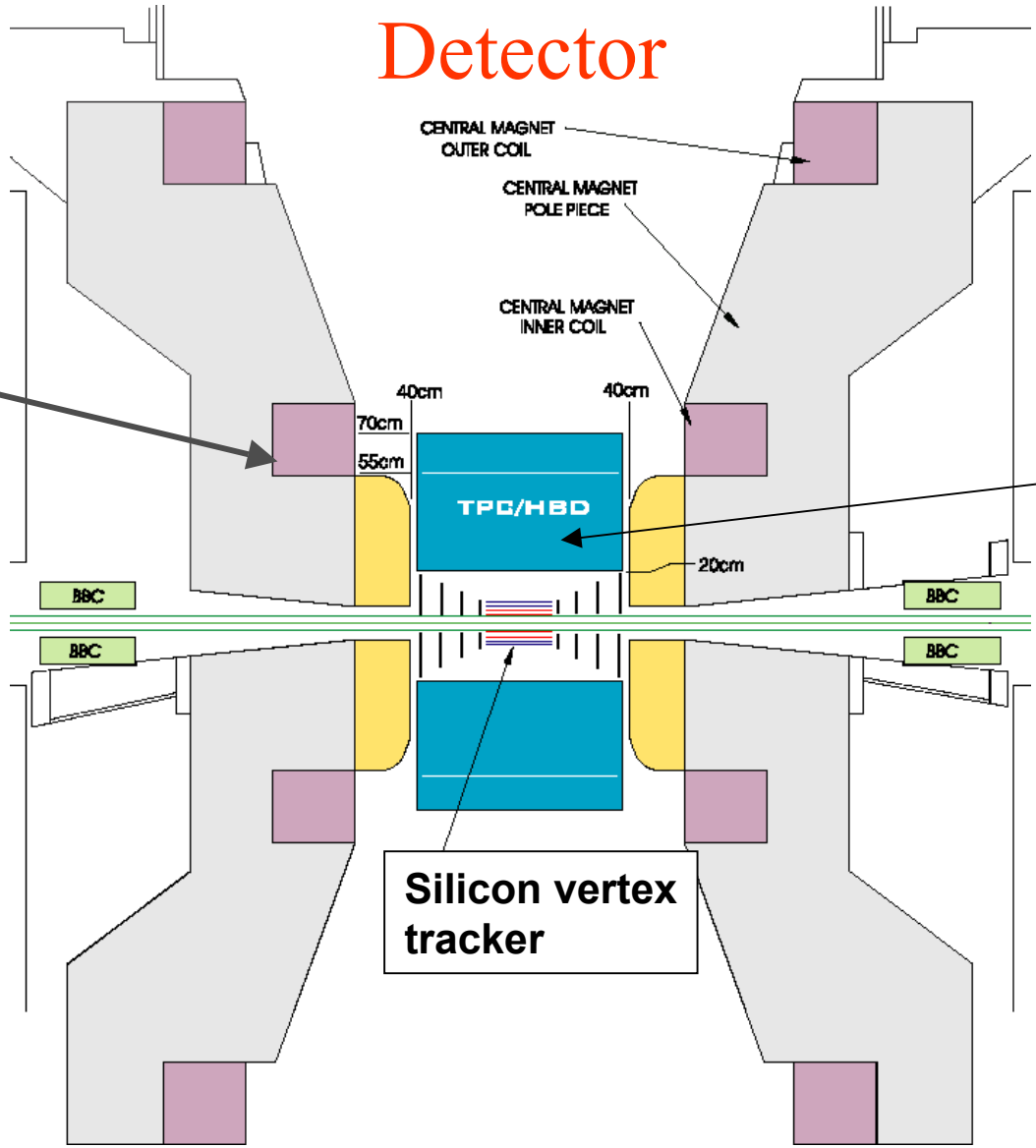
- Increased tracking coverage over 2π in azimuth and larger rapidity to measure jets and photon-jet correlations.

- Good rejection against Dalitz pairs and conversions, to measure low mass electron pairs and vector mesons.
  Hadron Blind Detector

- Particle id to high p_T:
  pi/K/p separation to p_T ~ 10 GeV/c
  electron identification to p_T > 10 GeV/c

- High rate data acquisition and triggering capabilities for studying rare processes.

PHENIX Inner Detector



Inner Coil creates a "field free" ($\int Bdl=0$) region inside the Central Magnet

TPC tracking coverage

2 pi azimuth
$-1.0<|y|<1.0$

$dp/p \sim 0.02p$

Silicon vertex tracker

S TAR II Detector for hard scattering and rare processes:

Upgrades will add…

- high rate capability
  >1000 central AA events/sec at Level 3 trigger… 100 ev/sec recorded
- enhanced detectors
  High Resolution Silicon inner vertex tracker
  Improved particle identification and TPC tracking

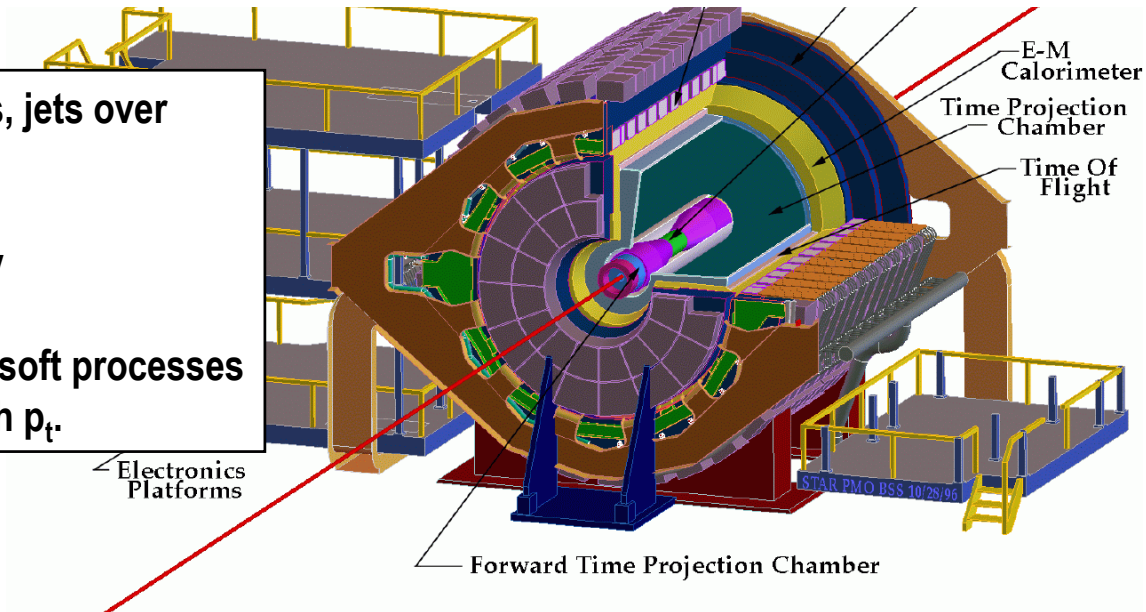
to its core strengths of …

- nearly complete event characterization and
  full azimuthal acceptance over a wide range of central rapidity.

Hadrons, electrons, photons, jets over Large solid angle

Identified Charm and Beauty

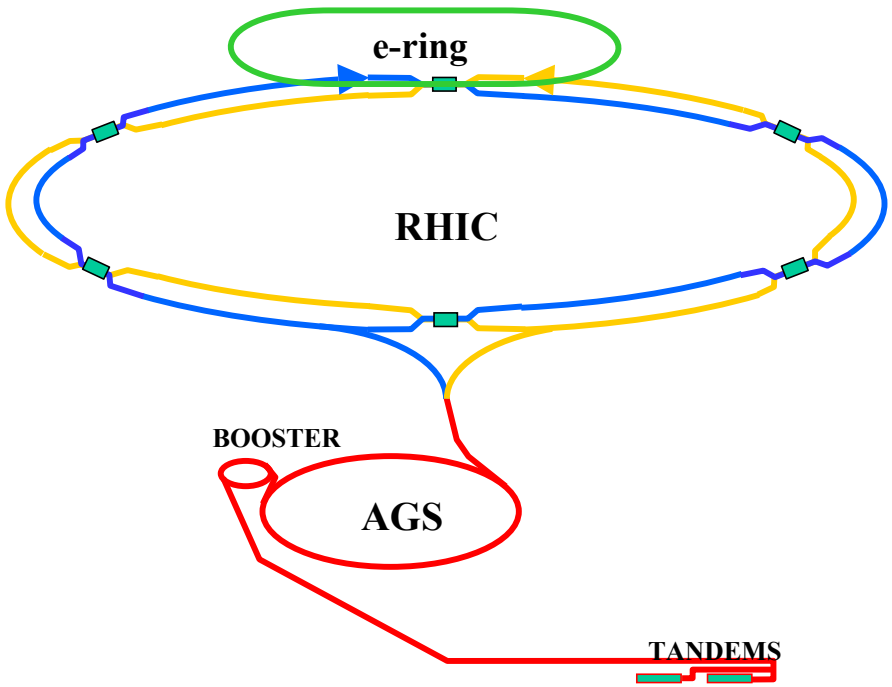
Acceptance extending from soft processes To pQCD regime of very high p_t.



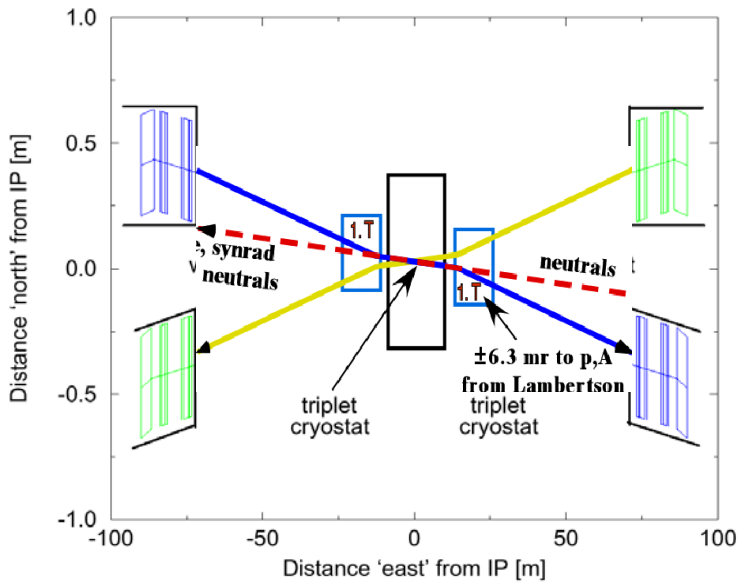
Electron Ion Collider: Workshop Feb. 2002

Explore limits of parton (gluon) density… Initial conditions in HI collisions.
Color Glass Condensate.

Polarized parton distributions.



Luminosity…
e proton: 4 x10^{32} cm^{-2}sec^{-1}
e Gold: 3 x10^{30} cm^{-2}sec^{-1}



(Polarized) Electron Beam:	**10 GeV**	**200 mA**
Polarized Proton Beam:	**250 GeV**	**300 mA**
Electron -cooled Gold Beam:	**100 GeV/u**	**120 mA**

Existing RHIC IP's fully negotiable for electron-ion collisions.

RHIC II Funding Plan…

As Presented to NSAC LRP Workshop March 2001

Proposed time scales and funding for RHIC Upgrades

Machine and Detectors… FY 2002 M$

Luminosity upgrade [RHIC II]	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	Totals
Electron Cooling				2.0	15.0	15.0	15.0	7.0			54.0
RHIC II Detector Upgrades				5.0	10.0	15.0	15.0	15.0	10.0	10.0	80.0
Subtotals		0.0	0.0	7.0	25.0	30.0	30.0	22.0	10.0	10.0	134.0
RHIC II R&D [Operating funds]											
Machine R&D		1.0	2.0	3.0							6.0
Detector R&D	0.5	1.0	2.0	2.0	1.0	1.0	0.5				8.0
Subtotals	0.5	2.0	4.0	5.0	1.0	1.0	0.5				14.0
Total RHIC II	0.5	2.0	4.0	12.0	26.0	31.0	30.5	22.0	10.0	10.0	148.0

This is the assumed ramp-up of luminosity from the Au-Au design value…

The first factor of 4 is funded from the on-going operations budget. The final factor of 10 is RHIC II:

	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11
Au-Au Luminosity	L_0	$2xL_0$	$4xL_0$	$4xL_0$	$4xL_0$	$4xL_0$	$4xL_0$	$4xL_0$	$40xL_0$	$40xL_0$

2001 NSAC Long Range Plan Recommendations

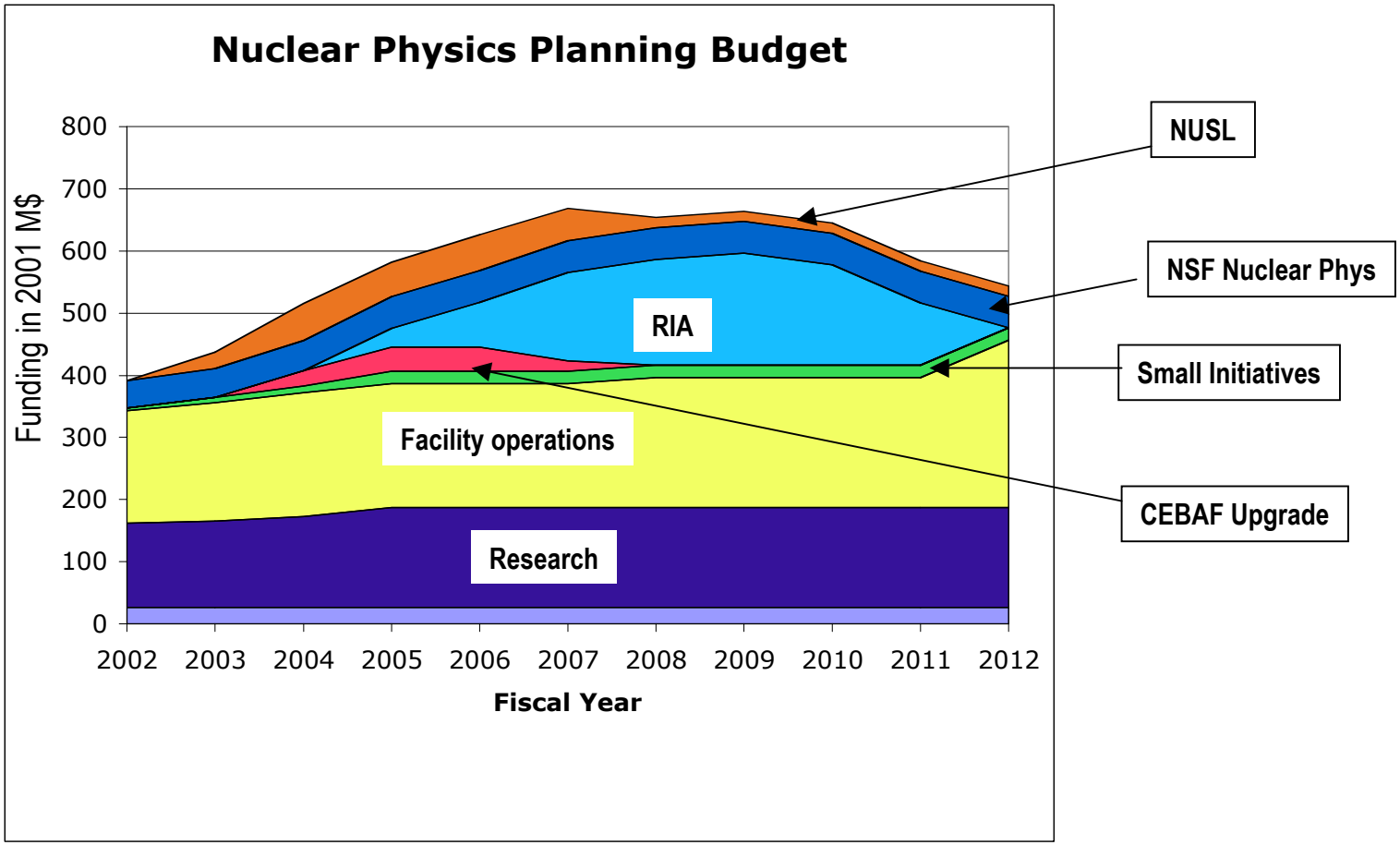
1. Increase support for facility operations, research, theory
2. Rare Isotope Accelerator (RIA):
   "RIA will require significant funding above the nuclear physics base. This is essential so that our international leadership positions at CEBAF and at RHIC be maintained."
3. Immediate construction of the world's deepest underground science laboratory.
4. Upgrade of CEBAF to 12 GeV "as soon as possible".

Other initiatives:

RHIC II: "…a significant enhancement of the luminosity at RHIC, together with upgraded detectors, may be necessary to fully investigate the properties of nuclear matter at high energy and density".

The Electron-Ion Collider: "…there is a strong consensus among nuclear scientists to pursue R&D over the next three years to address a number of EIC design issues".

2001 Long Range Plan



RHIC Program Review

By the Nuclear Physics Division of the U.S. DOE
Brookhaven National Laboratory
July 31 – August 2, 2002

Evaluate the quality, performance, and significance of the ongoing and planned RHIC program, in the context of the NSAC Long Range Plan for Nuclear Science and the national nuclear physics program.

Review Panel

Y. Akiba, KEK
J. Cameron, Indiana
H.-A. Gustafson, Lund
M. Gyulassy, Columbia
R. Kephart, Fermilab
C. Rode, JLAB
C. Whitten, UCLA

Statements from Review Close-out

- The results from RHIC during the past year are truly impressive…
- Concern that the local RHIC physics experimental groups are too "lean"
- "A multiyear plan for RHIC operations should be developed in full consultation with the user community".
- The full x40 increase in luminosity proposed for RHIC II "has not been defended on a physics basis… The elements of the RHIC II program should be physics driven."
- BNL and DOE should establish priority ordered lists of detector and accelerator upgrades. "BNL should work with DOE to develop methods to fund these incremental projects."

RHIC Upgrades: The Current View

Accelerator components:

EBIS – Build it quickly, with RHIC operating capital (e.g. AIP funds)

e-Cooling – Build it on a time scale similar to the RHIC II proposal, but as "Phase I" of EIC Project (eRHIC = "extended RHIC")

Detector components:

Begin Detector R&D program immediately – BNL R&D Advisory Committee to meet ~November 2002.

Detector Upgrades for 4 x $L_0 \Rightarrow$ 40 x L_0 -- Individual, proposal-driven projects.
($2M threshold for MIE; $5M threshold for "Major Project")

Detector Upgrades… Rough Time Scale

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
$<L_0$	L_0	$2L_0$	$4L_0$	$4L_0$	$4L_0$	$4L_0$	$4L_0$	$8L_0$	$16L_0$	$40L_0$